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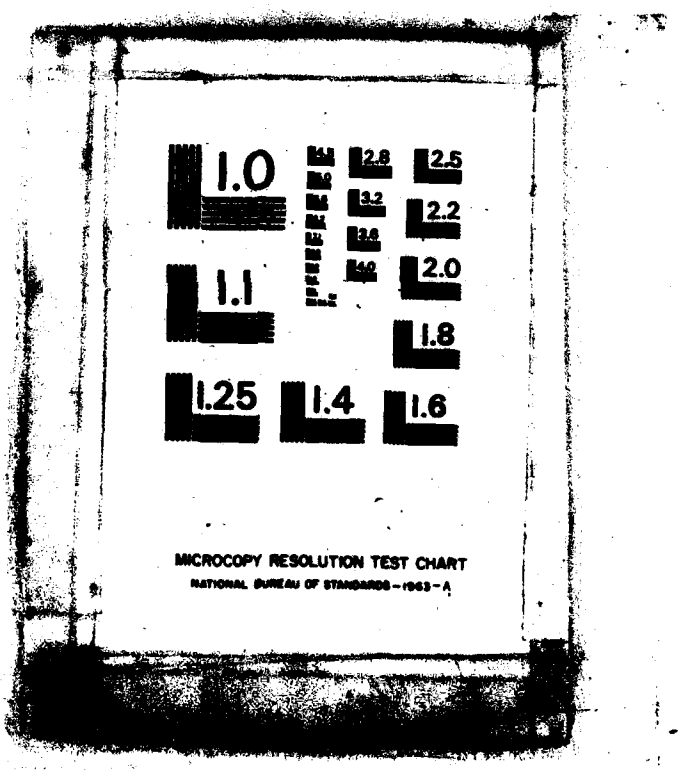
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Annual Progress Report

to the

Directorate of Mathematical and Information Sciences
Department of the Air Force
Air Force Office of Scientific Research (AFSC)
AFOSR/NM, Building 410
Bolling Air Force Base
Washington, DC 20332

For the grant AFOSR-82-0230

CONTROL AND IDENTIFICATION OF TIME VARYING SYSTEMS

Period covered: July 1, 1982 to June 29, 1983

from

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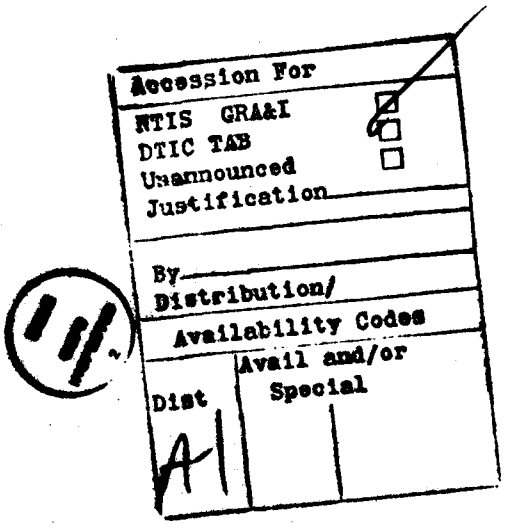
TABLE OF CONTENTS

		Page
I.	Summary of Progress and Continuing Research.	1
II.	Publications and Papers in Press.	3
III.	Ph.D. Theses	4
IV.	Supported Personnel	4
V.	Invited Papers and Seminars	4



I. Summary of Progress and Continuing Research

The over-all objective in this research program is to develop a step-by-step identification-control strategy for time varying dynamical systems which utilizes input-output data in block data form over short time intervals. Hence, the identification portion of this objective is to obtain computationally feasible algorithms for parameter identification which can work with strictly time limited data. The publications and papers listed in Section II, Ref. [1]-[5], are concerned in one way or another with this objective. Two fundamentally different approaches to this problem are used in these references; specifically, Ref. [1] and [3]-[5] utilize a projected integral equation error technique as an underlying means of converting a parametrized equation error model in differential operator format to integral equation format while obviating the necessity to deal with all unknown initial conditions for the time limited data. This is especially noteworthy for the identification of differential-delay equation (DDE) models, the subject of Ref. [3] and [4], since the state of a DDE system is essentially infinite dimensional. Here it is shown how the estimation of pure time delay can be decoupled from the estimation of the remaining system parameters for a class of DDE models using time limited input-output data. The formulation illustrates the use of the variable projection functional in nonlinear least squares theory.

The results in [3] and [4] are adapted in [1] to the classic problem of estimating time delay in two received signals when the

transmitting media are characterized by unknown transfer functions. Comparisons are also made with the Generalized Cross Correlation method, both with respect to analyses and simulation results, with the conclusion that the simple cross correlation method works at least as well as the parameter estimation or phase data methods when the transmitting media possess zero memory. However, the cross correlation method breaks down, as would be expected, when the media possess dynamical (nonzero memory) characteristics. Simulation results are presented which illustrate the superiority of the projected integral equation error technique in this case, although the computational requirements are understandably much more demanding than the cross correlation method.

The results to be published in [5] represents work in progress on the problem of estimating the target acceleration parameter in a two dimensional pursuit-evasion model when the range coordinate data is given over short time intervals. Here again the projected integral equation error technique is used along with a second order differential operator model for the equation error over each short time interval.

The results published in Ref. [2] stand in contrast with those represented by [1] and [3]-[5] in that the classical method of Shinbrot* is used to convert a linear differential equation to an algebraic equation involving integral-type functionals on the

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* Shinbrot, M. "On the Analysis of Linear and Nonlinear Systems", Trans. of the ASME, pp. 547-552, April 1957.

time limited input-output data. These functionals are characterized by a set of so called "modulating functions", and the main contribution in [2] is to show how trigometric functions can be used to define an appropriate set of modulating functions so that the functionals correspond to coefficients in a finite Fourier series of the data. This implies that a discretized approximation to these integrals can be made which points toward the use of the computationally efficient Fast Fourier Transform algorithm. The formulation can be extended to include the parameter identification of a class of linear time varying differential systems with periodic coefficients modeled by parametrized linear combinations of commensurable sinusoids. Preliminary simulation results indicate that this approach is surprisingly immune to random measurement noise. Further investigations are underway to analyze the effects of random measurement noise on the estimation accuracy.

II. Publications and Papers In Press

[1] Wuu, C. Y. and Pearson, A. E., "On Time Delay Estimation Involving Received Signals," Proc. of 1983 IEEE Inter. Conf. on Acoustics, Speech and Signal Proc., pp. 871-874, Boston, MA, April 1983. (Full Length version submitted to the IEEE Trans. on Acoustics, Speech and Signal Processing, Revised Sept. 1983.)

[2] Pearson, A. E. and Lee, F. C., "Time Limited Identification of Continuous Systems Using Trigonometric Modulating Functions," Proc. of Third Yale Workshop on Applications of Adaptive Systems Theory, pp. 168-173, New Haven, CT, June 1983.

[3] Pearson, A. E. and Wuu, C. Y., "Some Computational Aspects in Identifying Differential Delay Systems," Proc. of 1983 American Control Conf., pp. 1255-1256, San Francisco, CA, June 1983.

[4] Pearson, A.E. and Wuu, C. Y., "Decoupled Delay Estimation in the Identification of Differential Delay Systems." (Submitted to Automatica, Aug. 1983.) This is a full length version of [3] above.

[5] Pearson, A.E. and Ezzio, L. A., "Estimating Target Acceleration In Intercept Problems Using Modal Equation Errors." To appear in Proc. of 1983 IEEE Conf. on Decision and Control, San Antonio, TX, Dec. 1983.

III. Ph.D. Theses

Wuu, C. Y., "A Finite Time Parameter Estimation Scheme for Systems and Signals with Unknown Time Delays," Brown University, August 1982.

IV. Supported Personnel

Y. A. Fiagbedzi	Research Assistant
F. C. Lee	Research Assistant
A. E. Pearson	Professor of Engineering and Principal Investigator
C. Y. Wuu	Research Assistant

V. Invited Papers and Seminars

Nov. 18 1982: Rensselaer Polytechnic Institute, "Parameter Identification for a Class of Nonlinear Differential and Differential-Delay Systems." Seminar in the Electrical, Computer and Systems Engineering Department.

June 16, 1983: Yale University, "Time Limited Identification of Continuous Systems Using Trigonometric Modulating Functions" (with F. C. Lee). An invited paper for the Third Yale Workshop on Applications of Adpative Systems Theory, New Haven, CT.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: AFOSR-TR- 83-0936	2. GOVT ACCESSION NO.: AD-A135223
3. RECIPIENT'S CATALOG NUMBER:	
4. TITLE (and Subtitle): Control and Identification of Time Varying Systems	5. TYPE OF REPORT & PERIOD COVERED: Annual Technical Report July 1, 1982 - June 29, 1983
	6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): Allan E. Pearson, Principal Investigator	8. CONTRACT OR GRANT NUMBER(s): AFOSR-82-0230
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Professor A. E. Pearson, Division of Engineering, Brown University, Providence, RI 02912	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 61102F; 2304/A1
11. CONTROLLING OFFICE NAME AND ADDRESS: Air Force Office of Scientific Research/NM, Building 410, Bolling AFB, DC 20332	12. REPORT DATE: June, 83
	13. NUMBER OF PAGES: 6
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release, distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Estimating Target Acceleration in Pursuit Evasion Models, Identification of Differential Delay Systems, Identification of Time Varying Systems, Time Delay Estimation in Received Signals.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Research results are summarized for system parameter identification utilizing time limited input-output data. The results stem from two fundamentally different approaches, one of which stems from a projected integral equation error formulation and the other from a modulating function formulation for converting differential equations to functional equations. Applications include the parameter identification of differential-delay systems, delay estimation in received signals, identification of time varying systems, and estimating target acceleration in pursuit-evasion problems.

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